AD-A119 167 NATIONAL BUREAU OF STANDARDS WASHINGTON DC F/G 20/5
LASER COOLING AND TRAPPING OF NEUTRAL ATOMS.(U)
SEP 82 W D PHILLIPS N00014-82-F-0005
UNCLASSIFIED NL

1 OF 1

END
DATE FILMED
10-82
DTIC

AD A119167

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A119167	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LASER COOLING AND TRAPPING OF NEUTRAL ATOMS		5. TYPE OF REPORT & PERIOD COVERED interim 1 Oct. 81 - 30 Sept. 82
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) William D. Phillips		8. CONTRACT OR GRANT NUMBER(s) N00014-82-F-0005
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Bureau of Standards Washington, DC 20234		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N 11 RR011-03-03
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Physics Program Office Arlington, VA 22217		12. REPORT DATE September 1982
		13. NUMBER OF PAGES 3
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Approved for public release; distribution unlimited.

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

atomic beams, atom traps, frequency standards, high resolution spectroscopy, laser cooling

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Using a resonant, counterpropagating laser beam we have reduced the velocity of atoms in a neutral thermal sodium beam to 40 m/s, or 4% of their initial velocity. The "temperature" characterizing the atoms' relative motion was reduced to 70 mK.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

82 09 13 016

Annual Summary Report

on

LASER COOLING AND TRAPPING OF NEUTRAL ATOMS

by

William D. Phillips
National Bureau of Standards
Electrical Measurements and Standards Division

work supported by
Office of Naval Research
Contract No. N00014-82-F-0005
Task NR 407-007

Date of Report: September 1982

Response to Summary Questionnaire
(contract period ending 30 September 1982)

1. Principle Investigator: William D. Phillips

2. Contract Description: We are investigating experimental methods for laser cooling of neutral atoms, and possible applications of cooled atoms in trapping schemes, or slow beams, to high resolution spectroscopy and frequency standards.

3. The highest resolution spectroscopy is ultimately limited by processes which relate to atomic velocities such as second order Doppler shift and transit time effects. Laser cooling of ions in traps promises to deal with these problems, but there is a great deal of interest in achieving the same benefits for neutral species. Unfortunately compared to ions, neutrals interact very weakly with external electromagnetic fields, so that it is much more difficult to trap them. Proposed traps using laser fields and electrostatic fields have not yet been realized, and successful trapping in magnetic fields has never been put to practical use. Much of the difficulty centers on the very small energy depth of the neutral traps, and the difficulty in cooling atoms contained in such a trap, in contrast to the situation with ion traps. As a result, much of the interest now centers on the deceleration of a free atomic beam, either for direct use in high resolution spectroscopy or as a preparation for loading atoms into a trap.

4. The deceleration of an atomic beam is accomplished by directing a resonantly tuned laser opposite to a beam of neutral atoms. Sodium atoms are used because tuneable lasers at the sodium resonant frequency are available. Two main problems are encountered: First, as the atoms decelerate, they are Doppler shifted out of resonance with the laser and cease decelerating before a significant reduction in velocity has occurred. Second, because of the sodium hyperfine structure, atoms can be optically pumped by the laser into states which are not resonant, thus ending the deceleration. Our solution to these problems is to apply a spatially varying magnetic field along the common laser and atomic beam axis. When the laser is circularly polarized, the magnetic field prevents radiative transitions which would lead to adverse optical pumping. The spatial variation of the magnetic field provides a changing Zeeman shift which is used to compensate the changing Doppler shift so that the atoms stay in resonance with the laser as they decelerate.

5. During the past contract period, we have decelerated atoms from a thermal velocity of about 1000 m/s to 40 m/s. The velocity spread of the decelerated atoms corresponds to a temperature of 70 mK. The observed density of these very slow atoms is seriously reduced by divergence of the atomic beam and by scattering of the slow atoms by background gases. We are currently exploring ways of avoiding these difficulties, and of using the slow atoms for spectroscopy or trapping. If we limit the deceleration to a factor of two reduction in velocity, we can produce a ten-fold increase in atomic density per unit velocity interval by compressing the atomic velocity distribution into the lower velocity.

6. "Rapid Frequency Scanning of Ring Dye Lasers" by W. D. Phillips, Appl. Opt. 20, 3826 (1981).

"Laser Deceleration of Neutral Atoms" by W. D. Phillips and H. Metcalf, Bull. Am. Phys. Soc. 26, 1327 (1981).

"Laser Deceleration of an Atomic Beam" by W. D. Phillips and H. Metcalf, Phys. Rev. Lett. 48, 596 (1982).

"Laser Production of a Very Slow, Mono-energetic Atomic Beam" by J. V. Prodan, W. D. Phillips and H. Metcalf, to be published.

7. No extenuating circumstances.

8. No unspent funds are expected.

9. No graduate students are involved in this project.

10. The principle investigator is one of the scientists who receive partial support for the determination of the fine structure constant from the Department of Energy. Support under that grant is $15,000 for the period 1 July 1981 - 30 June 1982.

LME

8